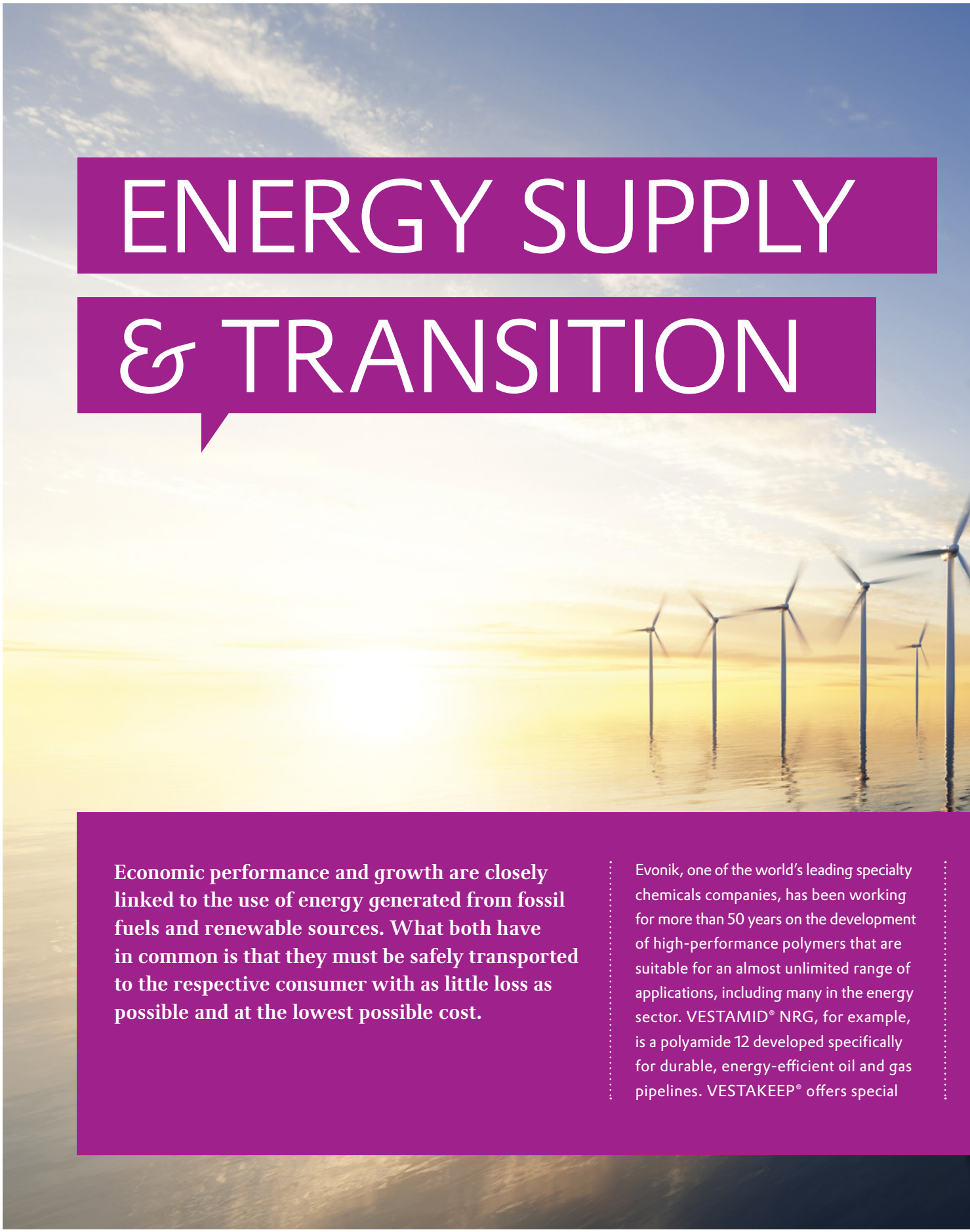
VESTAKEEP®
VESTAMID® NRG
VESTAPE®

POWERFUL SOLUTIONS
FOR EFFICIENT AND SUSTAINABLE ENERGY INFRASTRUCTURE

EVONIK
Leading Beyond Chemistry



ENERGY SUPPLY & TRANSITION

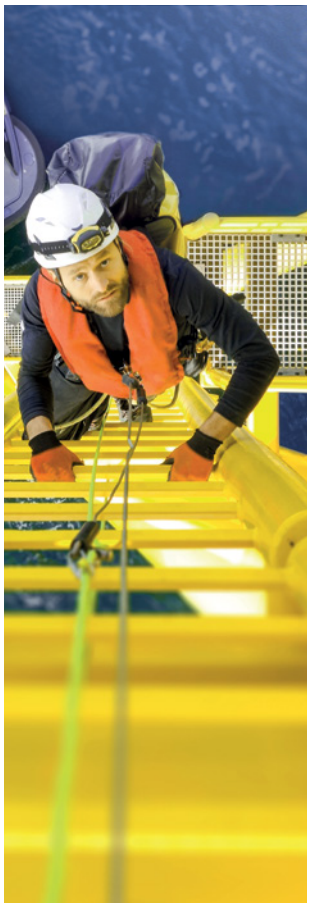
Economic performance and growth are closely linked to the use of energy generated from fossil fuels and renewable sources. What both have in common is that they must be safely transported to the respective consumer with as little loss as possible and at the lowest possible cost.

Evonik, one of the world's leading specialty chemicals companies, has been working for more than 50 years on the development of high-performance polymers that are suitable for an almost unlimited range of applications, including many in the energy sector. VESTAMID® NRG, for example, is a polyamide 12 developed specifically for durable, energy-efficient oil and gas pipelines. VESTAKEEP® offers special

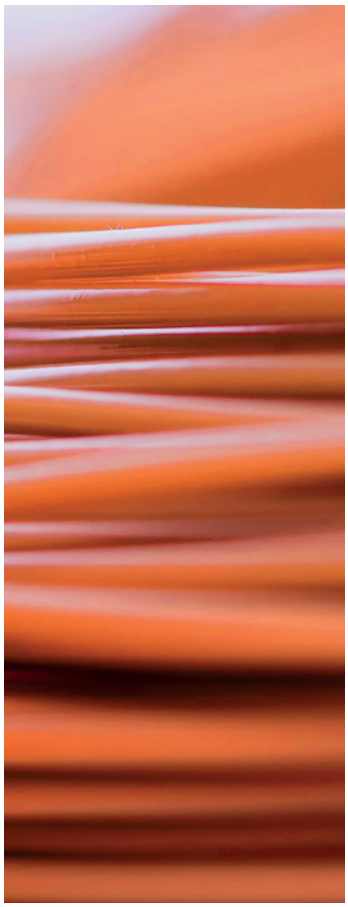
protection against corrosion or chemicals in high-temperature and high-pressure applications.

The decarbonization of the energy sector pursues the switch from fossil fuels to carbon-free energy by the second half of this century in order to limit climate change. For example, one way to reduce energy-related CO_2 emissions is to use wind in the deep sea. Hydrogen is produced on site at the wind farm and can be transported without major losses. For transport, Evonik has developed VESTAPE® for thermoplastic composite pipes that can withstand the enormous dynamic loads. In this way, we are continuously facing up to new challenges in energy transition.

CONTENT



POLYAMIDE 12 AND PEEK
TWO MATERIALS FOR THE TOUGHEST CHALLENGES



AT A GLANCE

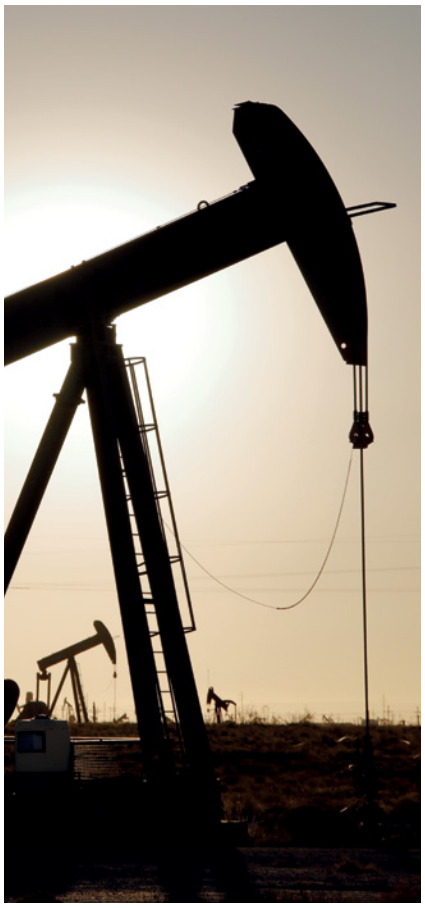
Polyamide 12

The classic applications of VESTAMID® PA12 (polyamide 12) range from safety-relevant automotive components to cable protection, parts in mechanical and industrial engineering, and use in sports and lifestyle applications. In particular, PA12 has proven its worth for use in air- and fluid-carrying lines in vehicles with nearly all well-known automotive manufacturers.

Its high chemical resistance and excellent mechanical properties make PA12 the ideal material for components that come into contact with hydrocarbon-containing media, such as crude oil and natural gas, and for hydrogen transport. Evonik has developed VESTAMID® NRG especially for large-diameter oil and gas pipelines. It has exceptional resistance to mechanical stress, stress fracture, and chemicals such as crude oil and gas, and its polymer character makes it insensitive to corrosion. Thanks to these properties, it can be used to protect the exterior and interior of onshore and offshore pipelines and serves as a matrix for carbon fiber tapes for thermoplastic composite pipes.

Relevant properties of VESTAMID® NRG for use in the oil and gas industry

- → Superior ductility
- → Good to excellent resistance to hydrocarbons as well as to salt solutions
- → Excellent fracture mechanical performance even under arctic conditions
- → High creep and pressure creep resistance
- → Extremely good resistance to slow crack propagation
- → Excellent heat aging resistance and aging properties in water
- → Applicable up to 85 °C (185 °F), higher temperatures should be tested individually
- → Easy to process

For detailed informations please visit our database

PEEK

VESTAKEEP® PEEK (polyether-etherketone) molding compounds are particularly suitable for applications in which extremely high mechanical, thermal, and chemical requirements must be met. As a result, their use ranges from automotive parts exposed to high frictional forces and high temperatures to composite components in the aero-space industry, wafer carrier applications and demanding cable sheathing in the electrical industry.

In the oil and gas industry, the compounds can be used to protect pipelines from corrosion and wear, even under high temperatures and pressure. VESTAKEEP® is the material of choice for anti-wear tapes in demanding unbonded flexible pipe designs. Other typical applications include sealing rings, compressor parts, and valve parts that meet the requirements of NORSOK M710.

Relevant properties of VESTAKEEP® for use in the oil and gas industry

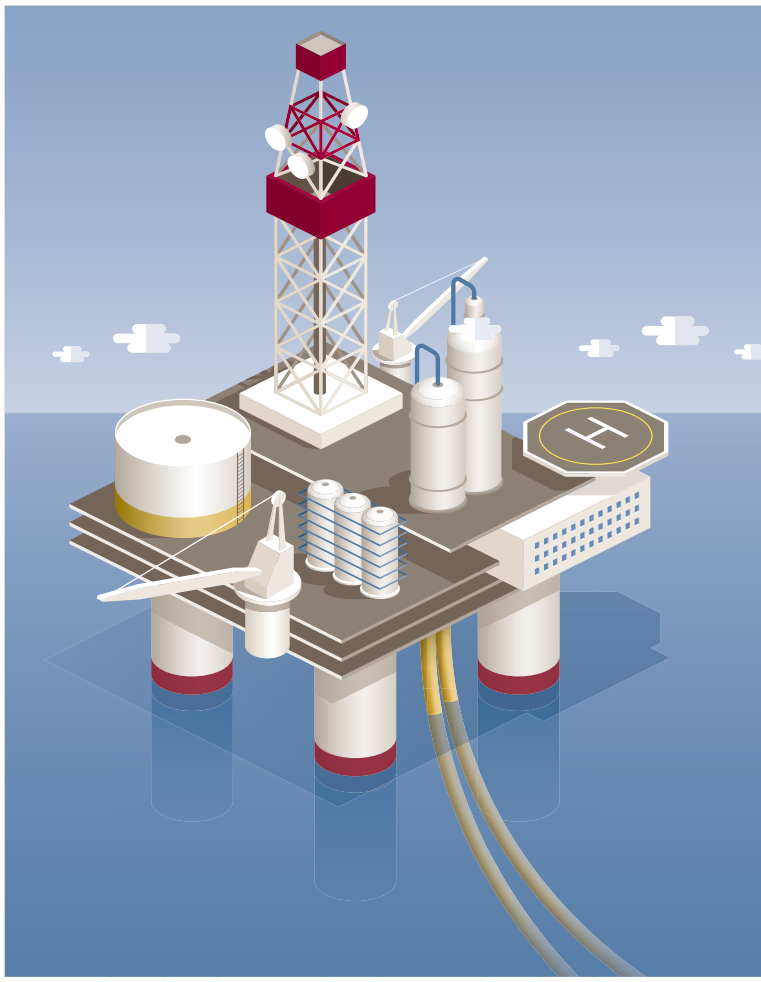
- → Reliable performance at high temperatures (260 °C/500 °F) and high pressure (1,000 bar/14,500 psi)
- → 50 % higher tensile modulus at 150 °C/302 °F
- → Excellent chemical and hydrolysis resistance
- → Low tendency to form stress cracks and low creep behavior at high loads
- → Excellent sliding friction behavior, minimal abrasion
- → Low compression set for good sealing properties

OFFSHORE

Operating in one of the toughest environments on the planet, offshore pipelines are critical to subsea transportation systems for continuous retrieval of resources from the depths of the ocean. From the deep waters of the Gulf of Mexico and hot reservoirs of Brazil to the low temperatures of the Arctic frontier, count on our proven products to reliably manage the extreme demands of offshore exploration, production and delivery.

PRODUCTS

DIVING DEEP
UNBONDED FLEXIBLE PIPES



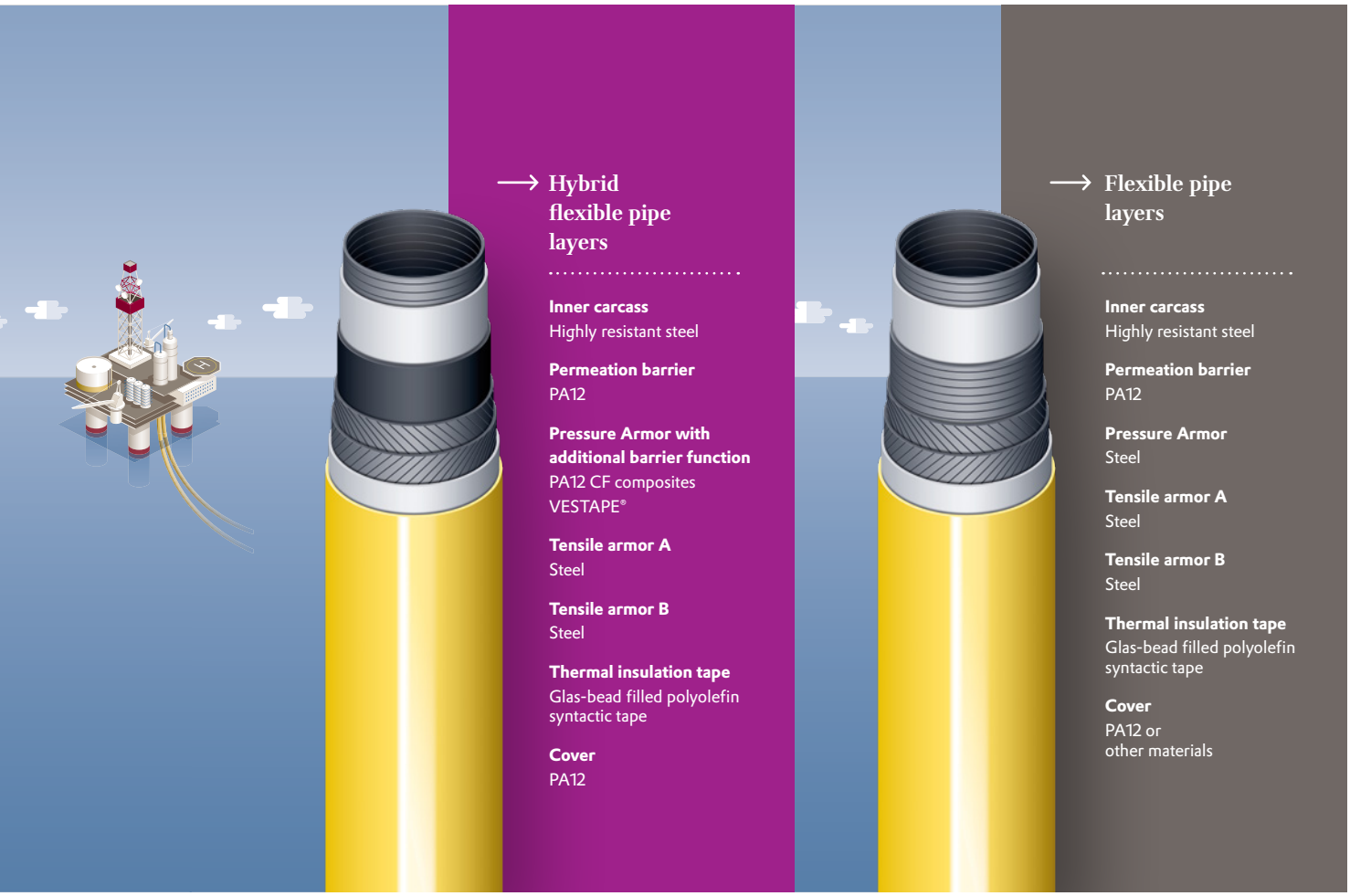
With layers of VESTAMID® NRG, risers and flowlines withstand high dynamic loads and come out on top for offshore applications.

Unbonded flexible risers and flowlines designed with the high molecular weight PA12 grade VESTAMID® NRG 1001 in their pressure sheath and outer jacket, can be used safely in applications ranging from dynamic sweet and sour hydrocarbon services to water and gas injection in accordance with API 17J. In recent years, several thousand kilometers of unbonded flexible pipe have been installed for several leading offshore oil companies without a single failure.

VESTAPE® is the composite material of choice as a fiber-reinforced layer/liner for hybrid flexible pipes for oil recovery from deep sea oilfields. In designing and manufacturing hybrid flexible pipes parts of the heavy steel solutions are replaced and allow lightweight constructions with significant weight savings compared to conventional.

MECHANICAL
PROPERTIES AT 23°C

Yield stress	23°C
Yield strain	23°C
Stress at break	23°C
Strain at break	23°C
Tensile modulus	23°C
Poisson ratio	23°C
	1s
Shore hardness A	15s
	1s
Shore hardness D	15s
	23°C
Compressive modulus	23°C
	60°C
Compressive modulus	60°C
IZOD impact strength	23°C
Density	



→ Hybrid flexible pipe layers

Inner carcass
Highly resistant steel

Permeation barrier
PA12

Pressure Armor with additional barrier function
PA12 CF composites
VESTAPE®

Tensile armor A
Steel

Tensile armor B
Steel

Thermal insulation tape
Glas-bead filled polyolefin syntactic tape

Cover
PA12

→ Flexible pipe layers

Inner carcass
Highly resistant steel

Permeation barrier
PA12

Pressure Armor
Steel

Tensile armor A
Steel

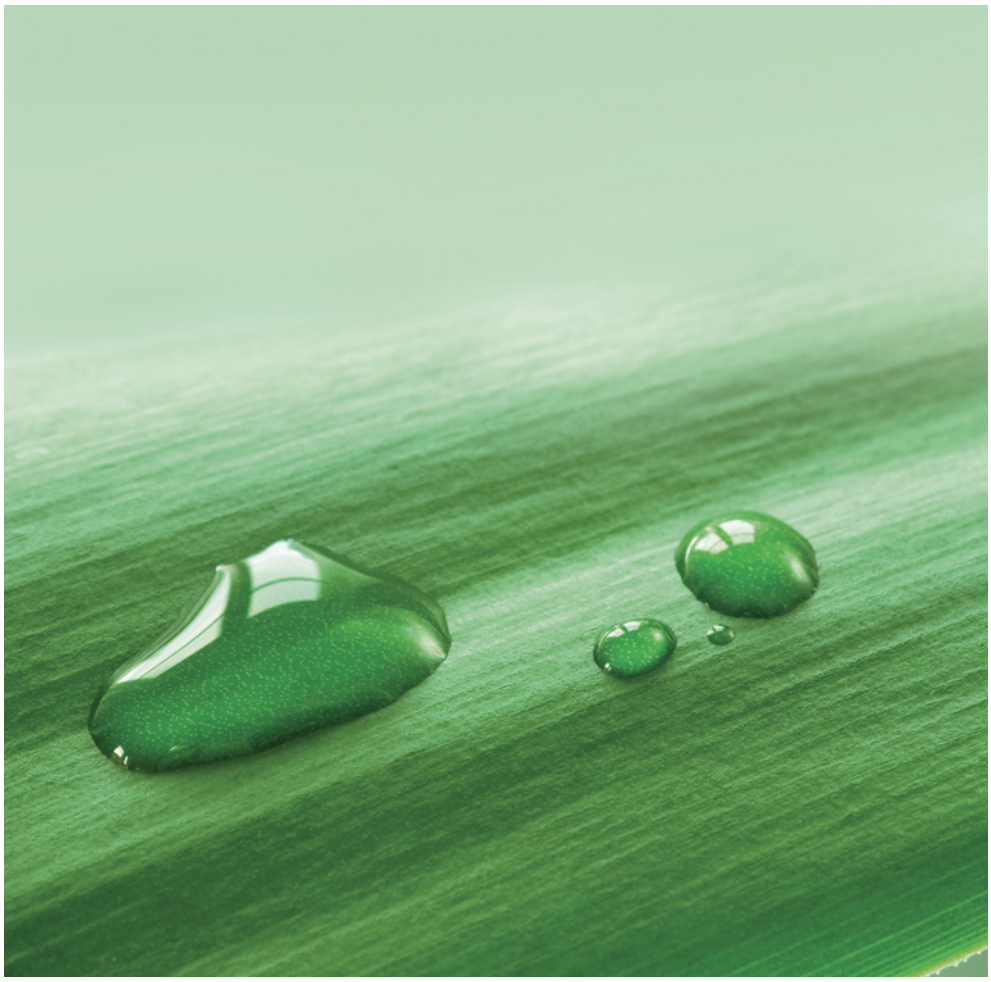
Tensile armor B
Steel

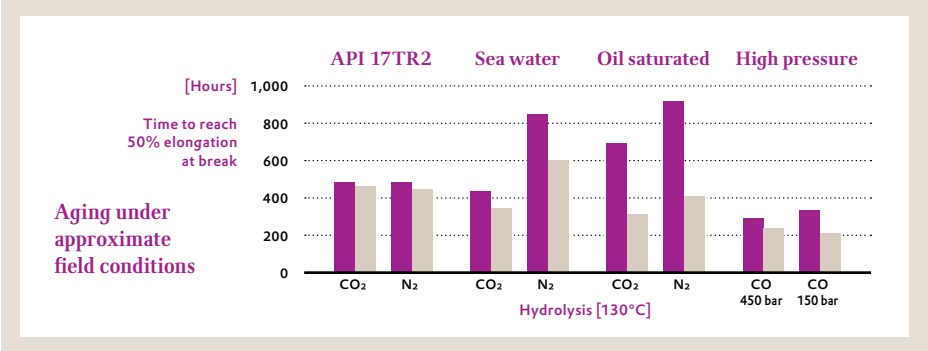
Thermal insulation tape
Glas-bead filled polyolefin syntactic tape

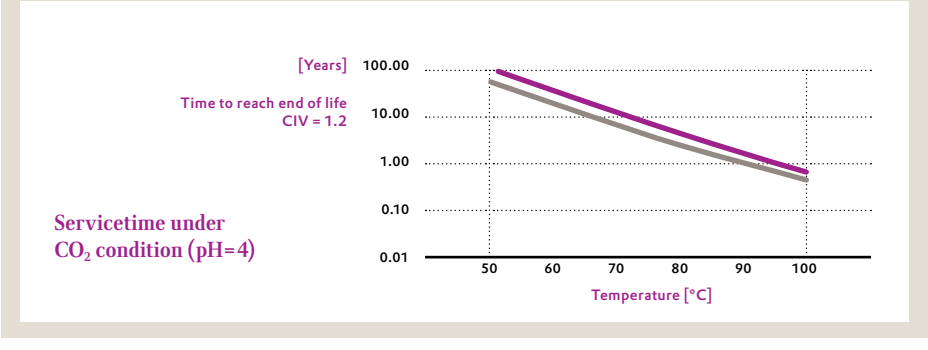
Cover
PA12 or other materials

Test method	VESTAMID® NRG 1001	Unit
ASTM D638	27.0	MPa
ASTM D638	32.5	%
ASTM D638	51.4	MPa
ASTM D638	>200	%
ASTM D638	450	MPa
ASTM D638	0.47	–
ASTM D2240	98	–
ASTM D2240	98	–
ASTM D2240	62	–
ASTM D2240	60	–
ISO 604	490	MPa
ASTM D695	490	MPa
ISO 604	300	MPa
ASTM D695	300	MPa
ASTM D256	1110	J/m
ASTM D792	1.02	g/m³

THERMAL PROPERTIES		Test method	VESTAMID® NRG 1001	Unit
Thermal conductivity coefficient		ASTM C177	0.25	W/(m·K)
Thermal expansion coefficient	23 - 55°C	ASTM E831	160	µm/(m·K)
Softening point Vicat A	10N	ASTM D1525	163	°C
Softening point Vicat B	50N	ASTM D1525	129	°C
Heat distortion temperature HDT A	0.45 MPa	ASTM D648	45	°C
Heat distortion temperature HDT B	1.8 MPa	ASTM D648	139	°C
Heat capacity DSC	23°C	ASTM E1269	2.15	J/(g·K)
Melt temperature	DSC	ASTM D3418	171	°C
Heat of fusion	DSC	ASTM D3418	63	J/g
Heat of fusion	100% crystalline	theoretical	210	J/g







Excellent aging properties in water (hydrolysis)

Due to its superior hydrolysis resistance, VESTAMID® NRG 1001 is able to withstand higher continuous service temperatures for a design life of 20 years. Extensive additional research confirmed the superior aging performance even under additional test conditions, such as supercritical CO_2. For dynamic applications, such as the riser, the end of lifetime is considered by reaching a CIV of 1.2 dl/g.

→ Top performance under tough offshore conditions

Products from the VESTAMID® NRG series exhibit excellent aging resistance in water, outstanding low-temperature ductility and fracture toughness and have extremely high resistance to slow crack growth in dynamic load cases even under hydrocarbons exposure.

VESTAMID® NRG 1001 has extremely high resistance to slow crack growth under real conditions in hydrocarbons. Its properties remain almost unchanged compared to virgin material. Polyolefins break down extensively in this respect.

Extensive research data and actual field experience confirm the excellent aging performance of VESTAMID® NRG 1001 in water. Recent comparative investigations in the API 17 TR2 Revision JIP show the depth of understanding and modelling basis of the aging behavior of this PA12 grade. The overall outstanding performance of PA12 is thus also documented and referenced in the most renowned offshore flexible standard.

Ductile even under arctic conditions

New challenges in oil field development are placing greater demands on exploration and production equipment. Extreme installation and operating temperatures must be considered when using flexible pipes on the Arctic frontier. VESTAMID® NRG 1001 allows operators to specify the most ductile and tough polyamide material for flexible pipes. Extensive fracture mechanics testing shows that it remains ductile even at -50 °C (-58 °F) and to the end of its intended service life. This excellent low-temperature ductility and fracture toughness contributes to safe installation procedures even in arctic conditions.

Proven track record

VESTAMID® NRG 1001 is used worldwide in oil and gas production. Applications range from risers to flow lines to jumpers, with pipe size, operating pressure, and installation environment playing a major role. The fluids transported in product pipelines vary from oil, oil/water to oil/water/gas multiphase fluids. As a result, VESTAMID® NRG 1001 is widely accepted as the material of choice in the flexible pipe industry, and leading oil companies such as Petrobras, Chevron, ExxonMobil, Shell, and Equinor are typical end users. In general, VESTAMID® NRG 1001 offers both the designer and operator of flexible pipes a safe and reliable material.

DYNAMIC DUO
THERMOPLASTIC COMPOSITE PIPES

With VESTAPE® tapes and VESTAMID® NRG, thermoplastic composite pipes (TCP) achieve the intrinsic corrosion resistance and strength needed to meet even the challenges of the ultra-deep sea.

Thermoplastic composite pipes for the offshore oil and gas industry are becoming increasingly important. Today, these types of flexible pipes are reliably used for short- and long-term applications, including as risers, jumpers, injection lines, flowlines and other service lines in subsea settings.

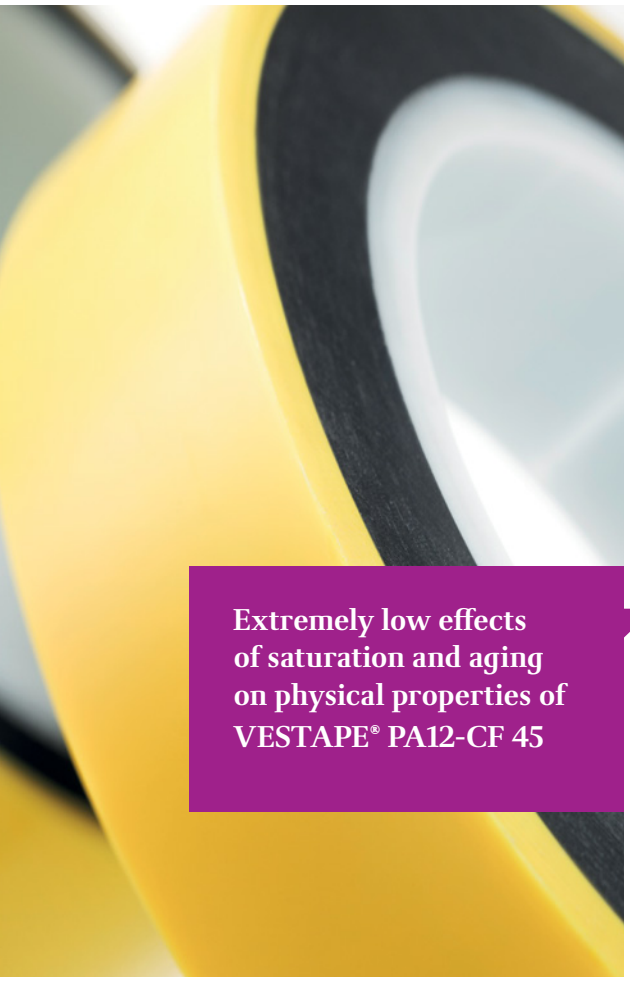
VESTAPE® PROPERTIES	VESTAPE® PA12-CF45	Unit
Thickness	0.25	mm
Fiber volume content	45	%
Density	1.36	g/m³
Tensile modulus	95	MPa
Tensile strength	1,750	MPa
Strain at break	1.8	%

Reliability in new technologies

Since VESTAMID® NRG has already proven itself in subsea applications, its beneficial properties were logically transferred to TCP construction. VESTAMID® NRG performs several functions in the composite pipe:

- → Liner material for multiphase operation
- → Matrix material for the reinforcement layer (VESTAPE®)
- → Cover material that protects the reinforcement layer from environmental influences

Evonik's VESTAMID® NRG 3001 and 4101 can be used, respectively, as liner and cover layer material and are certified according to DNV-ST-F119 for thermoplastic composite pipes.



Extremely low effects of saturation and aging on physical properties of VESTAPE® PA12-CF 45

Evonik has also developed a customized PA12 grade that serves as a matrix material for VESTAPE®, the high-quality unidirectional fiber-reinforced tapes for the reinforcing layer. VESTAPE® PA12-CF45 for oil and gas, hydrogen, and carbon capture and storage (CCS) applications features advantages in fiber impregnation, fiber-matrix bonding, and hydrolysis resistance. (Learn more about hydrogen and CCS applications in the chapter Energy Transition.)

The advantages of VESTAPE® PA12-CF45 are particularly evident where unchanged material properties are required over a wide temperature range and in long-term applications. In particular, they show their full potential between -20 °C (-4 °F) and 80 °C (176 °F), even in harsh environments, such as aggressive liquids and gases.

The figures show that the effects of saturation and aging on the physical properties of a composite made of VESTAPE® PA12-CF45 are extremely low, even at arctic and high temperatures. Its proven high resistance vs Rapid Gas Decompression (RDG) events on laminate and pipe level especially vs CO_2 adds to the use envelope as it is ideally suited also for gas injection service in recovery or sequestration. This provides the industry with a new corrosion insensitive tool to handle even the most demanding ultra-deep-water applications while bringing installation and operation costs to a minimum.

VESTAPE® PA12-CF45 is also qualified for demanding use in both static and dynamic TCP applications in accordance with DNV-ST-F119, with data that can be used for any design and load case.

Relative change of the mechanical properties of VESTAPE® PA12-CF45 at different temperatures and environmental conditions

* Aged until the end-of-life in worst case environment (representative NORSOK M-710 hot aromatic sour fluid incl. hydrocarbons, H_2O, H_2S, CO_2) and saturated in same environment for swelling and softening. Tested in situ to avoid evaporation.

ONSHORE

Environmental challenges in onshore oilfields include high pressures, high temperatures, UV-exposure, corrosion and more. Explore our collection of products for onshore pipeline systems to manage project challenges, while also keeping costs low and performance high – delivering economic benefits for installation, maintenance and long-term operation.

PRODUCTS

DIGGING DOWN DOWNHOLE THERMOPLASTIC LINERS FOR TUBING

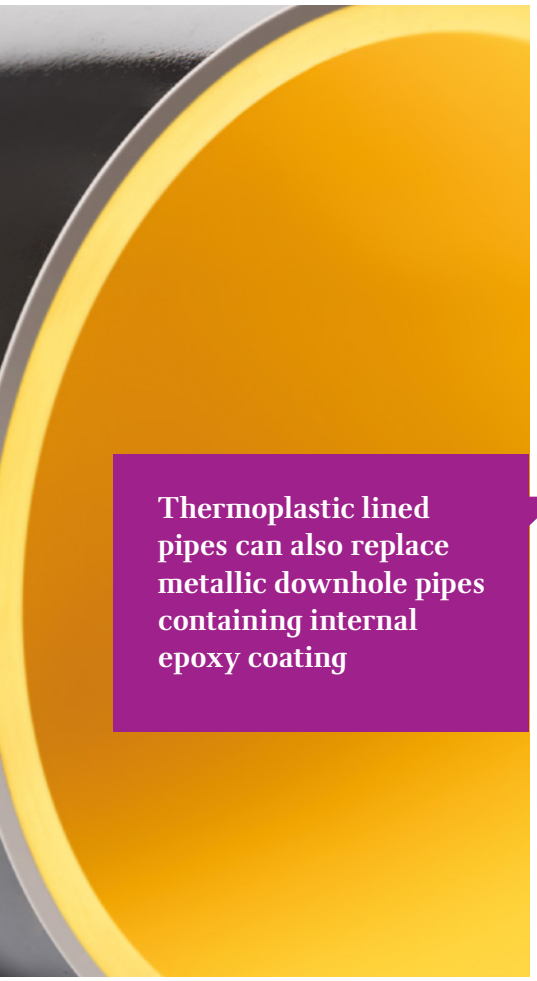
Our high-performance polymers used as liner material in downhole pipes will always minimize oil well interventions.

Evonik's high-performance polymers VESTAMID® NRG 3001 and VESTAKEEP® 5000 G can be used as liners for downhole tubing in injection and production wells under demanding conditions that include High Pressure High Temperature (HPHT) and chemical resistance.

Injection wells can include Water Alternating Gas (WAG) as an Enhanced Oil Recovery (EOR) method, where the gas phase has a very high CO_2 content and high pressure. Thermoplastic lined pipes are excellent for replacing expensive metallic corrosion resistant alloys (CRA) and clad pipes.

Overall, thermoplastic liners reduce well maintenance frequency and operating costs, thereby increasing the economics of oil wells.

- They act as a barrier to protect the carbon steel pipe from corrosion.
- They are highly resistant to damage from wear, such as abrasion from sand and wireline work, and impacts from sucker rods, connection piercing, make-up and wireline work.
- They reduce rod friction on pipes, extend the fatigue life of the sucker rod, and reduce lifting costs because less energy is required to pump the well.
- Their smooth inner surface causes less pressure drop than pure API tubing, and no kerosene is deposited in the tubing bore.
- Against rapid gas decompression (RGD), thermoplastic liners are more resistant than thermoset composite liners or coatings.
- Compared to metallic CRA, the lead time for installation is shorter.



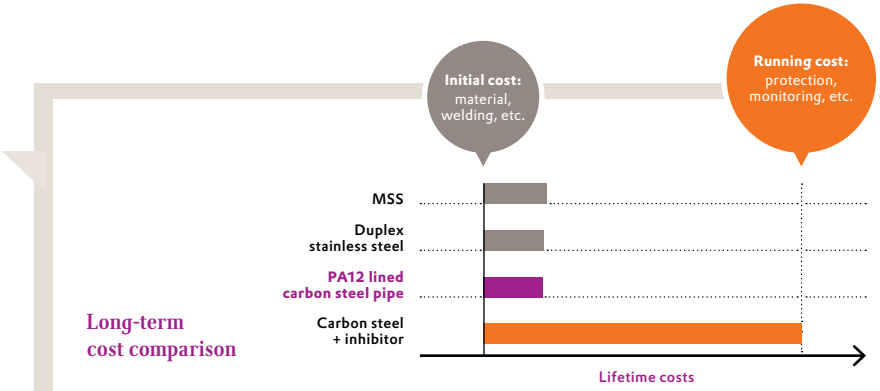
Thermoplastic lined pipes can also replace metallic downhole pipes containing internal epoxy coating

	VESTAKEEP® VESTAMID® NRG	Epoxy Coating
Support strategy	Self-supporting system, no adhesion to host pipe required, no plasticizer to support dimensional stability	Liquid application in a thin layer relying on the adhesion of the epoxy resin to host pipe surface, often an additional primer is required
Layer thickness	Thick compared to coating, wide range of thicknesses available, depending on requirement: 5 to >10 mm	Maximum of about 300 µm
Abrasion resistance	PA12 has excellent abrasion resistance. It also provides long lasting protection due to the thickness of the liner.	Epoxy coating has weak abrasion resistance, moreover, due to the low thickness the material can wear out very quickly.
Local blisters	Are not possible due to the nature of a liner (thick wall, no coating relying on adhesion), very ductile	Is frequently reported, especially if the host tube surface has not been adequately prepared (adhesion problems); the sensitivity is also supported by the brittleness of the epoxy resin.
Lifetime	Depending on the operating conditions, a service life of more than 20 years is possible.	Abrasion and blistering are the main reasons for coating failure, often lasting only 3 to 5 years.

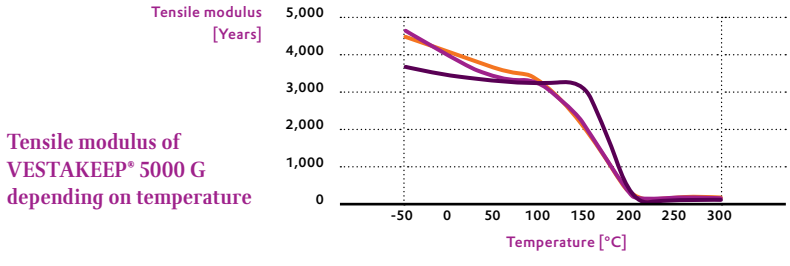
VESTAKEEP® PEEK for high-temperature high-pressure (HTHP) applications

VESTAKEEP® 5000 G is the ideal candidate for liners in downhole pipes operating under HTHP conditions, replacing expensive CRA-lined pipes. Due to its high ductility and abrasion resistance, VESTAKEEP® lined pipes can operate under conditions of up to 260 °C (500 °F).

Thermoplastic lined pipes can also replace metallic downhole pipes containing internal epoxy coating. The table shows the advantages of using VESTAMID® NRG and VESTAKEEP® as liners.



Long-term cost comparison



Tensile modulus of VESTAKEEP® 5000 G depending on temperature

● VESTAKEEP® L4000G ● VESTAKEEP® 5000G ● PEEK high viscosity

REINFORCED VERSATILITY REINFORCED THERMOPLASTIC PIPES

Reinforced Thermoplastic Pipes (RTP) reach a new level of stability thanks to our VESTAMID® NRG lining, especially when operating with hydrocarbons.

Reinforced thermoplastic pipes are used as flowlines, gathering and injection lines. They are replacing steel pipe solutions in these onshore applications due to their light weight, spoolability, ease of installation, which takes 20 percent less time, and lower operating costs, as maintenance is often not required. There are numerous designs on the market which aim to transport different media: water, hydrocarbons, gas, or a mixture of both. Most designs consist of three layers: lining, reinforcement and cover.

Use with sweet and sour hydrocarbon multiphase services

Common RTP designs use HDPE or PE-RT as the lining material. This results in operating temperature limitations, especially in light oil applications, and gas permeation issues. When transporting multiphase fluids, gas permeability can limit the maximum possible operating pressure of PE-based RTP designs. Not so with VESTAMID® NRG 3001 and 3901 as liner materials: they are developed specifically for such applications. This PA12 grade has excellent barrier properties against benzene, toluene and xylene – also known as BTX – as well as methane, carbon dioxide, hydrogen sulfide and their mixtures. These sub-

Lining

Single or multilayer liner made of PA12 or PE in full contact with the liquid. The non-corrosive material acts as a barrier.

Reinforcement

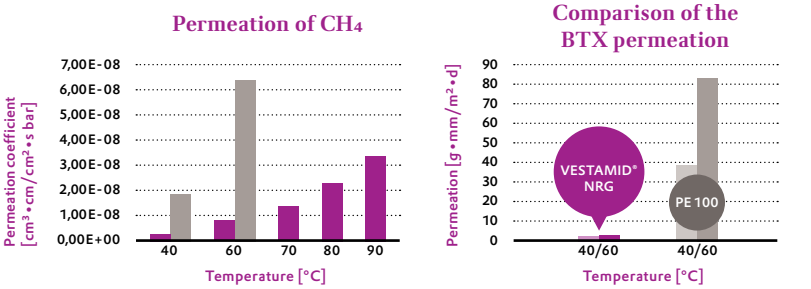
Metallic or non-metallic reinforcing tapes made of glass fiber, aramid fiber, steel wire, or PA12. In order to achieve very high-pressure resistance, metallic reinforcements are usually used.
Since these are susceptible to corrosion, non-metallic technologies are desirable, especially for acid oil services.

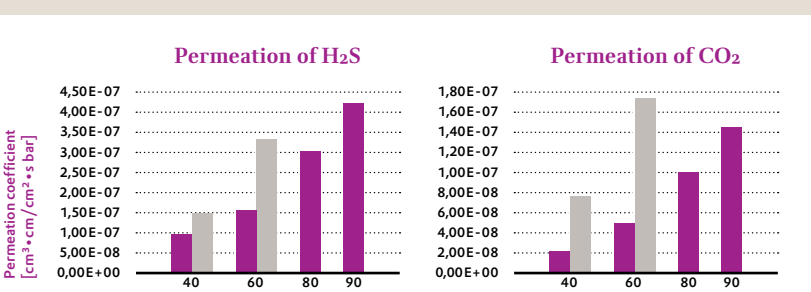
Cover

The covering protects the reinforcement from external impacts such as scratches, soil conditions and UV radiation.

stances are components of gas condensates and can cause environmental problems. The figures show how VESTAMID® NRG liners reduce permeation of these components compared to PE-based RTP systems.

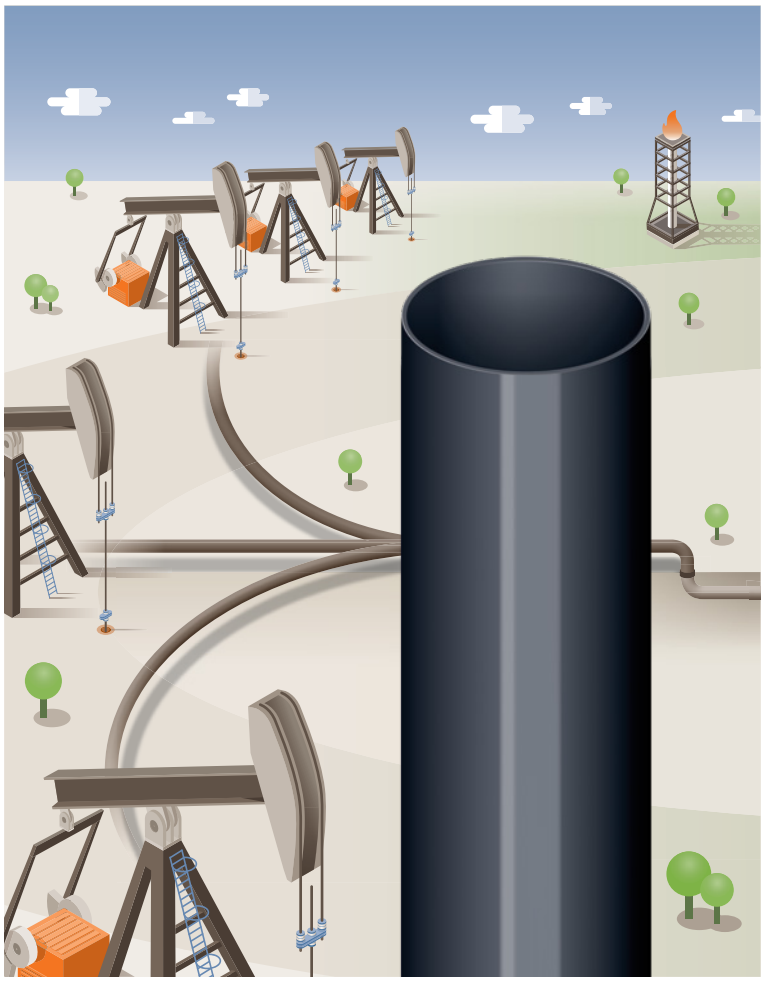
In addition, VESTAMID® NRG 3001 and 3901 exhibit very low swelling, which gives the RTP liners very high stability. The high fluid compatibility, thermal dimensional stability, and permeation resistance reduce the risk of failure during service life, for example due to collapse and buckling. On top, VESTAMID® NRG also prevents paraffin formation, which improves oil recovery by reducing downtime. VESTAMID® NRG is fully tested according to API 15S.





● PA12 ● HDPE

UV-RESISTANT GATHERING LINES



Pipelines made of VESTAMID® NRG can keep the cost of above-ground gathering and flow lines low in onshore oilfields.

Gathering and flowlines are used in rural areas to transport crude oil, natural gas, or multiphase fluids from the point of production, the wellhead, to a central collection point. Due to relatively high pressures and flow rates, this has historically been a market for carbon steel pipes, which must be protected against corrosion with appropriate measures during their service. To avoid these issues plastic pipes are now usually used.

VESTAMID® NRG 5901 line pipes save costs

Evonik has developed the UV-resistant VESTAMID® NRG 5901 grade for this application, as it is suitable for above-ground installation. Compared with coated carbon steel pipes, the cost is about 30 % lower because no cathodic corrosion protection is required, and installation can be carried out using low-cost techniques similar to HDPE pipe systems.

However, unlike polyethylene pipe, VESTAMID® NRG 5901 pipe can be used at much higher pressures, up to 22 bar (315 psi), for unregulated gas supply systems. According to the TR4 listing of the Plastics Pipe Institute (PPI, USA), the long-term hydrostatic design basis (HDB) of polyamide 12 is rated for temperatures up to 80 °C (180 °F).

System design factors and maximum allowable operating pressure for PA12 line pipes

PA12 LINE PIPES		Temperature			Unit
		73 - 104	104 - 140	140 - 176	°F
		23 - 40	**40 - 60**	**60 - 80**	**°C**
System design factors (DF) for PA12 line pipes according to ASTM F3524	**DF**	0.5	0.5	0.5	
	HDB	3,150	2,000	1,600	
Estimation of the PA12 maximum allowable operating pressure for the transportation of dry gas gathering and oil water (FSF = 1)	**SDR 17**	197 / 13.6	125 / 8.6	100 / 6.9	psi / bar
	SDR 13.5	252 / 17.4	160 / 11.0	128 / 8.8	psi / bar
	SDR 11	315 / 21.7	200 / 13.8	160 / 11.0	psi / bar
	SDR 9		250 / 17.2	200 / 13.8	psi / bar
	SDR 7.3			254 / 17.5	psi / bar
Estimation of the PA12 maximum allowable operating pressure for the transportation of wet gas gathering, multiphase fluid and liquid hydrocarbon (FSF = 0.95)	**SDR 17**	187 / 12.9	119 / 8.2	95 / 6.5	psi / bar
	SDR 13.5	239 / 16.5	152 / 10.5	122 / 8.4	psi / bar
	SDR 11	299 / 20.6	190 / 13.1	152 / 10.5	psi / bar
	SDR 9		238 / 16.4	190 / 13.1	psi / bar
	SDR 7.3			241 / 16.6	psi / bar

VESTAMID® NRG 5901 complies with ASTM F3524 for PA12 pipe. The compound is colored black and UV-stable, so lines made of it can be buried or laid above ground without restriction. Since the pipes can be processed coiled from the roll and thermally welded, they can be laid using cost-effective methods. Accessories such as electrofusion and welding fittings are available immediately.

GLOSSARY

HDB	hydrostatic design basis at design temperature psi [MPa]
DF	system design factor
FSF	fluid service factor
DR	dimension ratio
MOP	design pressure psi [MPa]

The maximum operating pressure (MOP) for a certain application can be estimated by the equation below*

$$MOP = \frac{2 \times HDB \times DF}{DR - 1} \times FSF$$

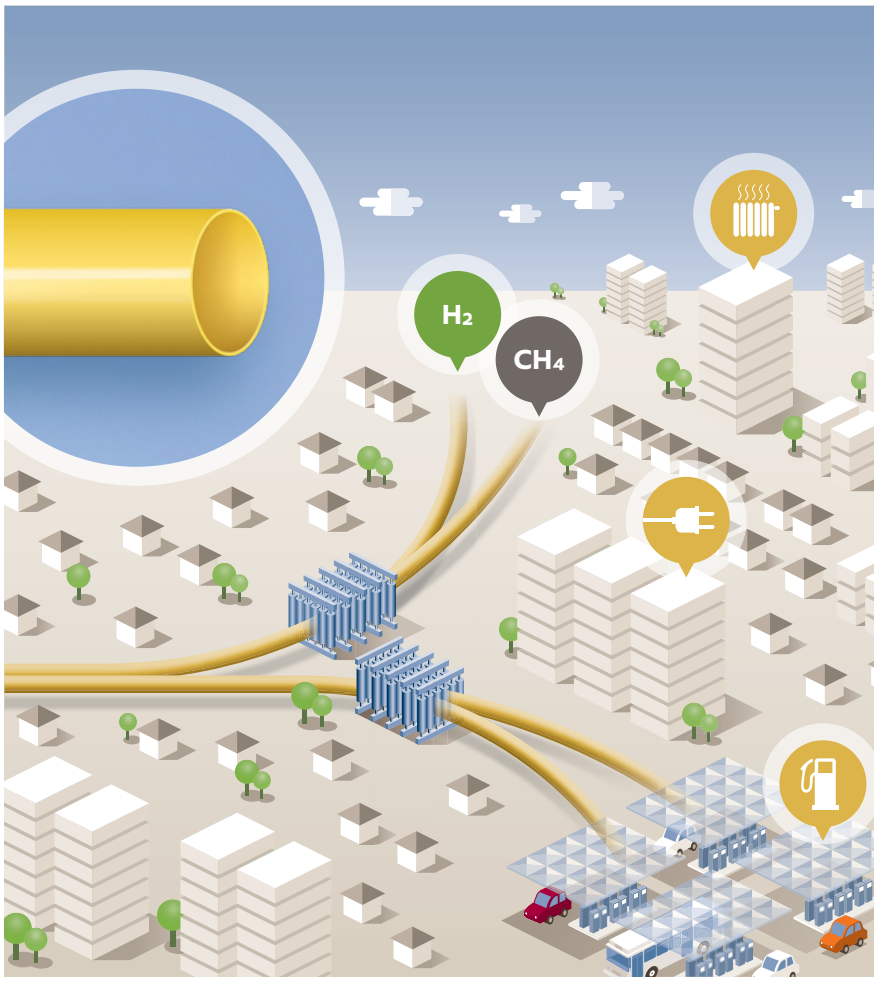
PA12 LINE PIPES FLUID SERVICE FACTORS	**FSF**
Dry gas gathering	1.00
Wet gas gathering	0.95
Multiphase fluid	0.95
Liquid hydrocarbons	0.95
Oilfield water	1.00

According to ASTM F3524

PPI TR-4 LISTING	Temperature	MDPE	HDPE	PA12 VESTAMID® NRG
	23°C / 73°F	1,250	1,600	3,150
	60°C / 140°F	1,000	800	2,000
	80°C / 180°F	N/A	N/A	1,600

* according to ASTM F3524

TOUGH GUY
GAS PIPES

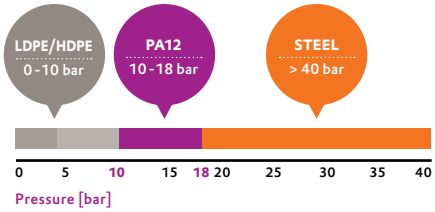


Pipes made of VESTAMID® NRG make gas distribution networks more affordable and profitable. In addition, they are suitable for transporting hydrogen, thus opening up opportunities for the hydrogen economy.

→ Learn more in the chapter „Energy Transition"

Until the arrival of PA12 VESTAMID® NRG 2101, steel had no competition for use as gas piping for pressures ranging between 10 and 18 bar (145 - 250 psi). However, the new material withstands operating pressures of up to 18 bar (250 psi), making it suitable for natural gas, biogas and hydrogen distribution lines. Accessories such as couplings and fittings are available and made of the same material.

Polyamide 12 arrives to offer the same advantages of polyethylene but for a higher pressure range



Pipes made of VESTAMID® NRG 2101 have undergone all of the usual tests for pressurized gas lines standardized both in the ISO 16486 and ASTM 2785 for raw materials, piping, fittings, valves, and suitability for use, as well as in guidelines for planning, handling, and installing PA12.

In addition, PA12 is listed in PPI TR-4 and in the PHMSA federal code, and fulfills many local standards such as IRAM (Argentina), ABNT (Brazil), ICONTEC NTC (Colombia), NOM (Mexico), SNI (Indonesia), CEN (Europe), DIN, DVS & DVGW (Germany), and ASME (US).

Leave your corrosion problems behind with PA12 long lasting material

Compared with steel, VESTAMID® NRG 2101 piping systems offer a superior range of economic benefits during installation, maintenance, and operation. The following have made the investment worthwhile for a number of gas companies.

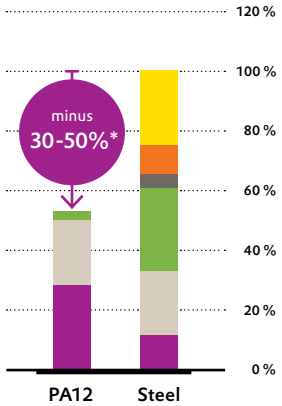
You can find further details in our separate brochure

VESTAMID® NRG
FOR GAS DISTRIBUTION PIPING SYSTEMS

VESTAMID® NRG pipes:

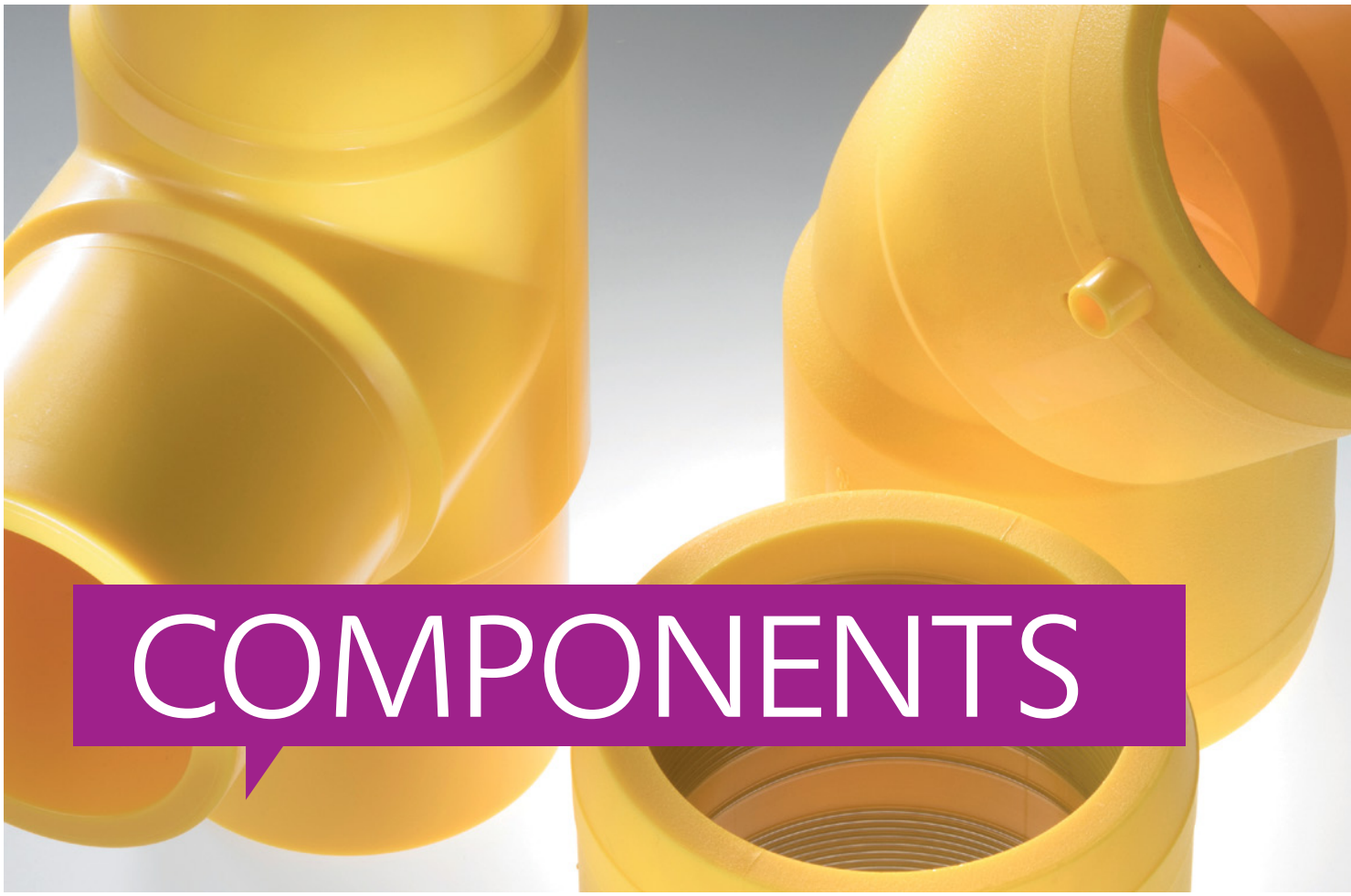
- → Are lightweight and easier to handle and transport.
- → Are delivered in coils, reducing therefore the number of field joints, increasing productivity, and thus significantly reducing installation costs.
- → Can be joined by butt fusion and electrofusion.
- → Do not suffer from corrosion. No need for active or passive corrosion protection.
- → Can be used with an array of low-cost, trenchless rehabilitation techniques, including horizontal directional drilling, slip lining, pipe bursting, etc.
- → Thus reducing installation and maintenance costs significantly (see cost comparison).

Cost comparison



* depends on project parameters

- Pipe & fittings
- Construction
- Installation
- Cathodic corrosion protection
- 50 years inspection
- 50 years corrosion



COMPONENTS

We offer three different materials for the demanding field of oil and gas components:

→ VESTAMID® NRG

→ VESTAKEEP® PEEK

→ Polyimide P84®

All from one material

Due to its high resistance to liquids and chemicals, easy processability and weldability, VESTAMID® NRG is a material for pipe fittings and other related components. Leading manufacturers offer a complete line of components that meet the most stringent ASTM and ISO product specifications. Transition fittings and anodic risers are available for tying into existing steel assets.

PEEK performance under HPHT conditions

In response to industry demand for higher-performance polyetheretherketone (PEEK) materials, Evonik has developed VESTAKEEP® 5000 series compounds. These compounds have a high molecular weight and offer an excellent combination of properties:

- → Excellent toughness, ductility and fatigue properties
- → Excellent chemical and wear resistance
- → Excellent long-term performance under HPHT and sour gas conditions
- → Easy to machine and process parts
- → Flame resistance, low smoke generation and toxicity

FOR PRECISE FIT COMPONENTS

Because of this property profile, especially its high ductility, VESTAKEEP® PEEK is particularly suitable for back-up rings and gaskets in a sealing package. In this application, the elastic recovery of the material results in a perfect seal without leakage. In comparison, the resilience of common PEEK molding compounds is much lower due to the permanent plastic deformation normally associated with a less ductile material. VESTAKEEP® PEEK grades therefore offer exceptional performance under difficult conditions such as chemicals and acid gas, high pressure and temperature (HPHT), dynamic loads, and complex assemblies.

Alternative to metal and ceramic

Polyimide P84® is an ideal material for metal and ceramic replacement. These compounds have a high molecular weight and offer an excellent combination of properties:

- → High strength, balanced mechanical properties, and creep behavior
- → Extremely high temperature stability in a performance range from -196 °C (-321 °F) to +300 °C (+572 °F)
- → Excellent long-term performance and dielectric properties
- → Ideal for applications requiring low wear and friction over a wide temperature range
- → Easy to machine parts and direct formed near net shapes

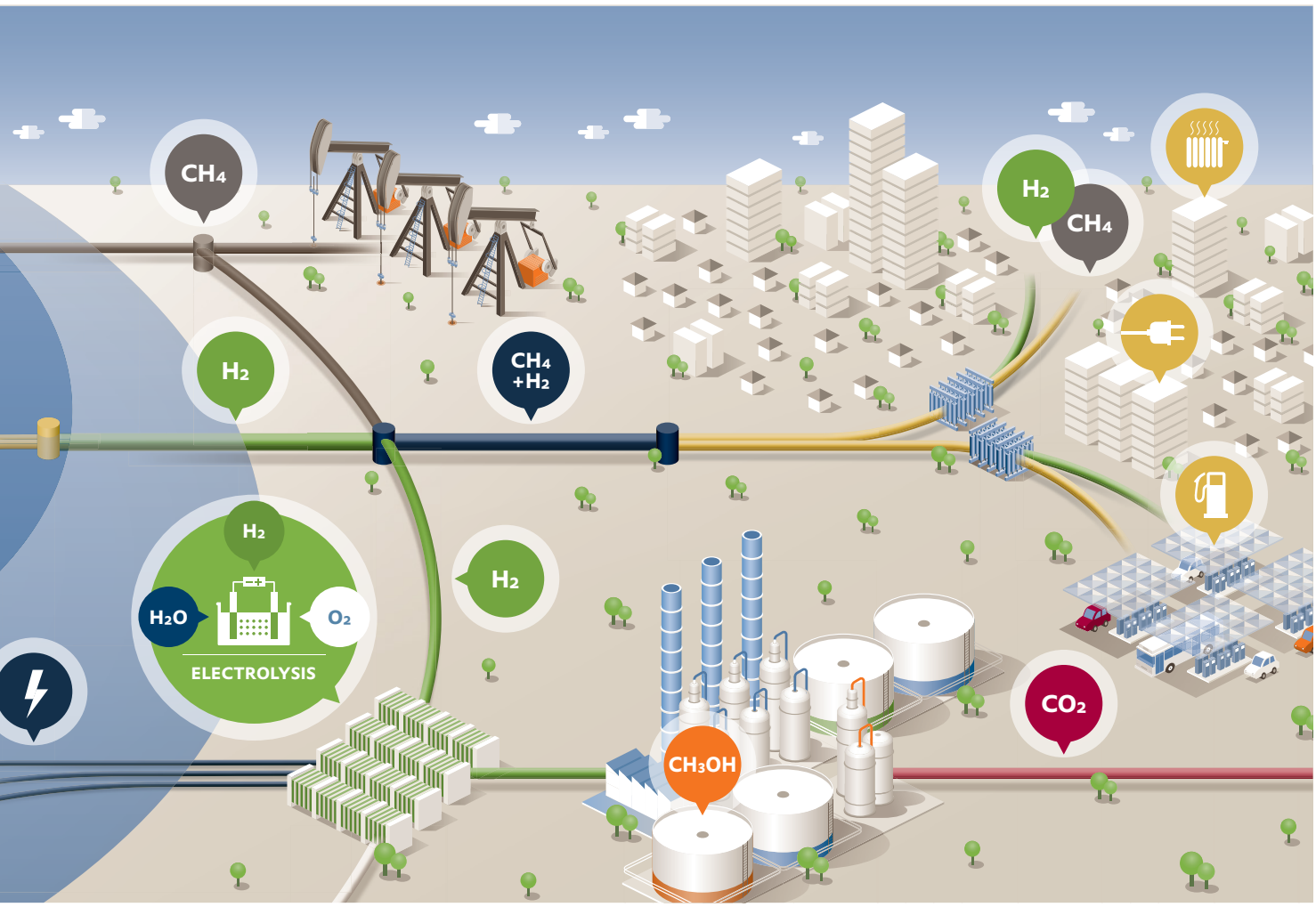
ENERGY TRANSITION
HYDROGEN TRANSPORTATION AND CARBON CAPTURE, UTILIZATION AND STORAGE

Dynamic pipelines designed with VESTAMID® NRG and VESTAPE® PA12-CF tapes make the management of H_2 and CO_2 much more reliable.

Many major industrialized nations have set themselves the goal of achieving climate neutrality by 2050 or at least carbon neutrality by 2060. Besides the governmental, political and financial pressure on all kind of industries, a lot of initiatives were founded in order to support the energy transition and to explore the most efficient ways to achieve the decarbonization goals. This finally means that the global energy infrastructure will be transformed dramatically, on- and offshore, with hydrogen and CCUS (Carbon Capture, Utilization and Storage) concepts being seen as promising enablers to a greener energy supply. Green hydrogen can be transported on- and offshore to supply emission-critical industries, such as heavy industry, and thus improve the carbon footprint of the companies involved. CO_2 on the other hand can be captured, transported, stored and in some cases re-used to contribute to substantially lower CO_2 emissions.

Evonik is actively supporting diverse decarbonization initiatives on governmental and industrial levels and is thoroughly investigating ways to provide respective material solutions for the "greener" energy infrastructure on- and offshore.

Wind is one of the energy sources that can help meet global climate goals. The strongest winds blow several miles from shore. As distance increases, the water gets deeper, giving floating wind turbines advantages. One disadvantage though is the transport route for the electricity generated: cables become a limiting factor. One solution to avoid energy losses is electrolysis directly on site at the floating offshore turbine. The resulting hydrogen can be transported via safe pipes and used directly on land for combustion or chemical processes or converted back to electricity and heat in fuel cells.



Thermoplastic composite pipes (TCP) made with the "Dynamic duo" VESTAPE® and VESTAMID® NRG are our solution for offshore hydrogen infrastructure

Transporting hydrogen poses some challenges for the pipes used: Hydrogen can embrittle steel, reducing its pressure resistance and fatigue strength. This has a negative impact on the service life of steel pipes, especially when pressure fluctuates due to hydrogen storage, as well as in freely laid pipelines.

This is not the case with TCP for hydrogen transport: Dynamic service in waves and weather is not affected. TCP have a fatigue life that far exceeds that of steel. In addition, the total cost of installation and the levelized cost of hydrogen (LCOH) are lower. In operation they require very little maintenance, resulting in an estimated high operating life of about 50 years.

For onshore transport, we benefit from our expertise in gas distribution

Building a large-scale hydrogen economy requires safe and reliable technologies. Since VESTAMID® NRG 2101 is an already established PA12 gas pipe material that has proven itself on the market worldwide, it is an obvious step to use it to address the upcoming challenges in hydrogen distribution. The extremely low and intrinsic permeation coefficient of VESTAMID® NRG 2101 tubes in contact with hydrogen or methane and mixtures of both over a suitable pressure range up to the maximum operating pressure helps to achieve this.

The tests were carried out by the DVGW Laboratories of the Gas Technical Institute (DBI-GTI) in accordance with DBI-GTI 109 2020-10. The results show a significantly reduced permeation coefficient for PA12 in direct comparison to other polymeric gas pipe products from the polyolefin class at the respective maximum operating pressures. As a result, VESTAMID® NRG 2101 pipes were awarded with the DVGW "H2ready" stamp.

H2ready® GEPRÜFT / TESTED

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